Appendix A. Agricultural Effects of Elevated Carbon Dioxide Levels

Appendix A

TABLE A - 1

Emissions Summary by Source and Gas (in thousands of tons)

Source	1990				2010			
	Carbon Dioxide	Methane	Nitrous Oxide	Carbon Dioxide Equivalent	Carbon Dioxide	Methane	Nitrous Oxide	Carbon Dioxide Equivalent
Energy Related								
Residential	9,970			9,970	12,939			12,939
Commercial	5,870			5,870	9,100			9,100
Industrial	22,560			22,560	32,270			32,270
Transportation	46,637			46,637	66,080			66,080
Coal Mining		10		114		11		121
Subtotal				85,151				120,510
Materials Production Related								
Cement Production	244			244	618			618
Lime Production	456			456	456			456
Aluminum Production	1,350			6,507[†]	1,150			3,560
Land fills	1,416	310		4,827	1,944	102		3,066
Forest Long-Term Products	14,160			14,160	15,180			15,180
Forest Short-Term Products	4,400			4,400	3,900			3,900
Forest Residue	14,200			14,200	15,400			15,400
Forestry Slash Burns	1,063	2	> 1	1,063	403	1	> 1	427
Net Annual Forest Growth	(42,600)			(42,600)	(51,500)			(51,500)
Subtotal				3,013				(9,511)
Agricultural Related								
Range Cattle		55		608		55		608
Dairy Cattle		21		228		21		228
Beef Cattle		12		133		12		133
Other		15		160		15		160
Dairy Manure		46		506		46		506
Broilers & Layers		4		44		4		44
Beef Cattle Manure		2		18		2		18
Swine Manure		1		13		1		13
Other Manure		> 1		3		> 1		3
Fertilizers			3	790			3	790
Field Burning		6	> 1	90		6	> 1	108
Subtotal				2,593				2,503
Land-Use Related								
Convert Forests to Other Uses	4,300		> 1	4,319	4,300		> 1	4,319
Sequestration in Forest	(2,680)			(3,800)	(8,440)			(8,440)
Reserves								
Wetlands		14		149		14		146
Subtotal				668				(3,975)
Total Net Carbon Dioxide Equivalent Emissions				**91,425**				**109,527**

[†]Includes a carbon dioxide equivalent of 5,157 thousand-tons and 2,410 thousand-tons of carbon tetrafluoride in 1990 and 2010, respectively.

Agricultural Effects of Elevated Carbon Dioxide Levels

TABLE A - 2

Relative Yield Increases of Carbon Dioxide Enriched Crops†

Crop	Yield Ratio of CO_2 Enriched Crops to Control Crops		
	Lower Limit 95% Confidence	Mean	Upper Limit 95% Confidence
Flower Crops			
carnation	1.05	1.09	1.13
chrysanthemum	1.03	1.06	1.09
rose	1.11	1.22	1.33
Fruit Crops			
cucumber	1.22	1.30	1.38
strawberry	0.96	1.22	1.54
tomato	1.15	1.20	1.24
C3 Grain Crops			
rice	1.13	1.25	1.39
wheat	1.22	1.37	1.53
Leaf Crops			
Lettuce	1.26	1.35	1.45
Swiss chard	1.30	1.97	2.13
Legume Seed Crops			
beans	1.29	1.82	2.59
peas	1.32	1.89	2.70
soybean	1.13	1.27	1.43
Root/Tuber Crops			
potato	1.25	1.64	2.14
radish	0.83	1.28	1.96

† From Kimball, Carbon Dioxide and Agriculture Yields: An Assemblage and Analysis of 430 Prior Observations. Kimball cautions that most of the studies reviewed analyzed plant growth in greenhouses or growth chambers. Open field plants might respond less because nutrient levels in general agriculture are lower than those in the indoor studies. On the other hand, they may respond more because light levels are generally higher outside.

Appendix B. Emission Reduction and Cost Calculations for Greenhouse Gas Reduction Strategies

Residential Sector

Space Heat In New Construction

TABLE B - 1

Reference Residential Energy Code†

	Climate Zone 1		Climate Zone 2	
Heat Type	**Electric Resistance**	**Other**	**Electric Resistance**	**Other**
Ceiling				
Flat	38	30	38	38
Vaulted	30	30	30	30
Wall	19	19	24	19
Floor	30	19	30	30
Slab on grade	10	10	10	10
Window				
Average U-value	U.40	U.65	U.40	U.60
Window area (percent floor area)	15%	21%	15%	17%
Doors	U.20	U.40	U.20	U.40

†R values unless otherwise noted. The insulation levels represent base energy code requirements. However, several alternative options are available to meet minimum standards. In general, the options trade window area for window U-value; more window area requires more efficient windows.

TABLE B - 2

Alternative Upgrades to the Current Building Code

Class 40 Window	Windows with a U-value of 0.40
Class 35 Window	Windows with a U-value of 0.35
R-30 Floor (standard construction)	A standard framed floor insulated to an R-value of 30
R-38 Attic (std.)	A standard framed ceiling insulated to an R-value of 38
R-21 Wall (std.)	A standard framed wall insulated to an R-value of 21
R-49 Attic (std.)	A standard framed ceiling insulated to an R-value of 49
Class 28 Window	Windows with a U-value of 0.28
R-19 + R-5 rigid Wall (std.)	A standard framed wall with R-19 insulation in the wall cavity and R-5 rigid foam sheathing affixed to the wall exterior
R-38 Floor (I-joist construction)	A floor framed with wood I-joist and insulated to an R-value of 30
R-49 Vault Ceiling	A standard framed vault ceiling insulated to an R-value of 49
R-49 Attic (advanced construction)	An advanced framed ceiling insulated to an R-value of 49
Class 20 Window	Windows with a U-value of 0.20
6" Stress Panel Wall	An innovative construction technique using prefabricated panels (rigid insulation between plywood sheathing) erected on site
10" Stress Panel Vault	An innovative construction technique using prefabricated panels (rigid insulation between plywood sheathing) erected on site

TABLE B - 3

New Construction Conservation Measures for Homes with Natural Gas: Cost-Effectiveness in Zone 1†

Measure	NG Savings (therms/yr.)	Annual CO_2 Reduction (tons)	Cost of Measure	Annualized Cost of Measure	Annualized Capacity Benefit	Energy Savings Benefit	Net Annual Cost of Measure	Cost per ton CO_2 Reduction
Class 40 Window	68.2	0.415	$424	$28	$15	$17	($4)	NA
Class 35 Window	14.8	0.090	$118	$8	$3	$4	$1	$8
R-30 Floor (std)	23.3	0.142	$296	$19	$5	$6	$8	$59
R-38 Attic (std)	7.5	0.046	$106	$7	$2	$2	$3	$74
R-21 Wall (std)	10.2	0.062	$172	$11	$2	$3	$6	$103
R-49 Attic (std)	5.9	0.036	$154	$10	$1	$1	$7	$202
Class 28 Window	14.6	0.089	$400	$26	$3	$4	$19	$216
R-19+R-5 rigid Wall (std)	22.3	0.136	$812	$53	$5	$6	$42	$312
R-38 Floor (I-joist)	13.8	0.084	$511	$33	$3	$3	$27	$319
R-49 Vault Ceiling	4.9	0.030	$245	$16	$1	$1	$14	$458
R-49 Attic (adv.)	10.3	0.063	$662	$43	$2	$3	$38	$610
Class 20 Window	17.5	0.103	$1,140	$74	$4	$5	$66	$620
6" Stress Panel Wall	7.9	0.048	$726	$47	$2	$2	$44	$906
10" Stress Panel Vault	0.7	0.004	$862	$56	$0	$0	$56	$ 13,098

New Construction Conservation Measures for Homes with Natural Gas: Cost-Effectiveness in Zone 2

Measure	NG Savings (therms/yr.)	Annual CO_2 Reduction (tons)	Cost of Measure	Annualized Cost of Measure	Annualized Capacity Benefit	Energy Savings Benefit	Net Annual Cost of Measure	Cost per ton CO_2 Reduction
Class 40 Window	73	0.444	$276	$18	$16	$18	($16)	NA
Class 35 Window	20.2	0.123	$118	$8	$4	$5	($2)	NA
R-21 Wall (std)	14.1	0.086	$172	$11	$3	$4	$5	$53
R-49 Attic (std)	8.2	0.050	$144	$9	$2	$2	$6	$111
Class 28 Window	20.1	.0122	$400	$26	$4	$5	$17	$136
R-19+R-5 rigid Wall (std)	31.2	.0190	$812	$53	$7	$8	$38	$201
R-38 Floor (I-joist)	18.8	0.114	$511	$33	$4	$5	$24	$214
R-49 Attic (adv.)	14.4	0.088	$490	$32	$3	$4	$25	$287
R-38 Vault (hd)	6.8	0.041	$245	$16	$1	$2	$13	$308
Class 20 Window	24.1	0.147	$1,140	$74	$5	$6	$63	$429
6" Stress Panel Wall	11.1	0.067	$726	$47	$2	$3	$42	$623
10" Stress Panel Vault	1	0.006	$862	$56	$0	$0	$56	$9,146

†Assumes a 5 percent discount rate, conservation measures last 30 years, and natural gas costs $2.5 per MBtu. Numbers may not add exactly due to rounding.

TABLE B - 4

New Construction Conservation Measures for Homes with Electricity: Cost-Effectiveness in Zone 1

Measure	kWh Savings (per yr.)	Annual CO_2 Reduction (tons)	Cost of Measure	Annualized Cost of Measures	Annual Energy Savings Benefit	Net Annual Cost of Measure	Cost per ton CO2 Reduction
Class 35 Window	335.7	0.134	$118	$8	$11	($3)	NA
R-21 Wall (std)	186	0.074	$172	$11	$6	$5	$67
R-49 Attic (std)	135.5	0.054	$144	$9	$4	$5	$89
Class 28 Window	333.8	0.134	$400	$26	$11	$15	$112
R-38 Floor (I-joist)	314.9	0.126	$511	$33	$10	$23	$181
R-49 Attic (adv.)	239.3	0.096	$490	$32	$8	$24	$250
R-38 Vault (adv.)	112.5	0.045	$245	$16	$4	$12	$271
R-19 + R-5 rigid Wall (std)	366	0.146	$812	$53	$12	$41	$277
Class 20 Window	399.4	0.160	$1,140	$74	$13	$61	$381
6" Stress Panel Wall	180.2	0.072	$726	$47	$6	$41	$572
10" Stress Panel Vault	15.7	0.006	$862	$56	$1	$56	$8,846

New Construction Conservation Measures for Homes with Electricity : Cost-Effectiveness in Zone 2†

Measure	kWh Savings (per yr.)	Annual CO_2 Reduction (tons)	Cost of Measure	Annualized Cost of Measure	Annual Energy Savings Benefit	Net Annual Cost of Measure	Cost per ton CO2 Reduction
Class 35 Window	466.5	0.187	$118	$8	$15	($8)	NA
R-49 Attic (std)	186	0.074	$144	$9	$6	$3	$43
Class 28 Window	460.6	0.184	$400	$26	$15	$11	$58
R-19 + R-5 rigid Wall (std)	191.2	0.076	$172	$11	$6	$5	$63
R-38 Floor (I-joist)	430.9	0.172	$511	$33	$14	$19	$110
R-49 Attic (adv.)	328.2	0.131	$490	$32	$11	$21	$159
R-38 Vault (adv.)	154.1	0.062	$245	$16	$5	$11	$175
Class 20 Window	550.1	0.220	$1,140	$74	$18	$56	$254
R-33 Double Wall	567.3	0.227	$1,477	$96	$19	$77	$340
6" Stress Panel Wall	63.3	0.025	$554	$36	$2	$34	$1,340
10" Stress Panel Vault	22	0.009	$862	$56	$1	$55	$6,289

†Cost-Assumes a 5 percent discount rate, the conservation measures last for 30 years and a wholesale cost of electricity of $0.033. Numbers may not add exactly due to rounding.

TABLE B - 5

Carbon Dioxide Reduction for Cost-Effective New Construction Conservation Measures

	Zone 1	Zone 2
Units, 1998-2010	215,982	29,880
Proportion gas	0.36	0.36
Proportion electric	0.64	0.64
Number Units		
Gas	77,754	10,757
Electric	138,228	19,123
Nominal CO2 emission factor (tons/unit)		
Gas	0.505	0.567
Electric	0.134	0.187
Square foot scaling factor	1.57	1.57
Actual CO2 emission factor		
Gas	0.794	0.891
Electric	0.211	0.294
2010 CO2 reduction		
Gas	61,732	9,589
Electric	29,121	5,622
Total	**90,853**	**15,211**

Retrofit Conservation Measures For Existing Homes

TABLE B - 6

Retrofit Conservation Measures For Electrically Heated Homes: Cost-Effectiveness in Zone 1†

Measure	kWh Savings (annual)	Annual CO_2 Reduction (tons)	Cost of Measure	Annualized Cost of Measure	Energy Savings Benefit	Net Annual Cost of Measure	Cost per ton CO2 Reduction
Ceiling R-0 to R-19	11,296	7.658	$594	$38.64	$376.53	($337.89)	NA
Walls R-0 to R-11	4,821	5.729	$1,362	$88.60	$160.70	($72.10)	NA
Crawl Space R-0 to R-19	4,287	4.014	$2,361	$153.59	$142.90	$10.69	$6
Windows R-2.6	2,200	2.363	$5,187	$337.42	$73.33	$264.09	$300
Ceiling R-19 to R-30	787	3.700	$2,868	$186.57	$26.23	$160.33	$509
ACH .6 to .5	662	3.435	$2,664	$173.30	$22.07	$151.23	$571
Windows R-3	299	3.243	$3,082	$200.49	$9.97	$190.52	$1,593
Windows R-5	569	2.135	$6,258	$407.09	$18.97	$388.13	$1,705
Ceiling R-30 to R-38	181	3.362	$2,812	$182.92	$6.03	$176.89	$2,443
Wood to Metal Door	347	1.996	$6,819	$433.59	$11.57	$432.02	$3,113
Crawl Space R-19 to R-30	334	1.863	$7,683	$499.79	$11.13	$488.66	$3,658

Retrofit Conservation Measures For Electrically Heated Homes: Cost-Effectiveness in Zone 2†

Measure	kWh Savings (annual)	Annual CO_2 Reduction (tons)	Cost of Measure	Annualized Cost of Measure	Energy Savings Benefit	Net Annual Cost of Measure	Cost per ton CO2 Reduction
Ceiling R-0 to R-19	14,261	10.432	$594	$38.64	$475.37	($436.73)	NA
Walls R-0 to R-11	6,093	7.995	$1,362	$88.60	$203.10	($114.50)	NA
Crawl Space R-0 to R-19	5,471	5.807	$2,361	$153.59	$182.37	($28.78)	NA
Windows R-2.6	2,921	3.633	$5,187	$337.42	$97.37	$240.06	$205
Ceiling R-19 to R-30	1,021	5.398	$2,564	$166.79	$34.03	$132.76	$325
ACH .6 to .5	860	5.054	$2,664	$173.30	$28.67	$144.63	$420
Windows R-3	394	4.802	$3,082	$200.49	$13.13	$187.36	$1,189
Windows R-5	762	3.328	$6,258	$407.09	$25.40	$381.96	$1,252
Ceiling R-30 to R-38	238	4.959	$2,812	$182.92	$7.93	$174.99	$1,838
Wood to Metal Door	469	3.141	$6,819	$443.59	$15.63	$427.95	$2,281
Crawl Space R-19 to R-30	451	2.960	$7,683	$449.79	$15.03	$484.76	$2,687

† The available measures, their costs and energy savings taken from the 1991 Northwest Conservation and Electric Plan as was the transmission and distribution savings. Cost-effective conservation measures shaded.

TABLE B - 7

Retrofit Conservation Measures for Natural Gas Heated Homes: Cost-Effectiveness in Zone 1†

Measure	NG Savings (therms/yr.)	Annual CO_2 Reduction (tons)	Cost of Measure	Life of Retrofit Measure (years)	Annualized Cost of Measure	Capacity Benefit	Energy Savings Benefit	Net Annual cost of Measure	Cost per ton CO2 Reduction
Walls (R-0 to R11)	152	0.924	$764	30	$49.70	$33.32	$38.00	($21.62)	NA
Floor (R-0 to R-19)	171	1.040	$976	30	$63.49	$37.48	$42.75	($16.74)	NA
Low-Flow Shower	48	0.292	$45	12	$5.08	$1.45	$12.00	($8.37)	NA
Vent Damper	44	0.268	$142	12	$16.02	$9.64	$11.00	($4.62)	NA
Ceiling (R-11 to R-30)	99	0.602	$659	30	$42.87	$21.70	$24.75	($3.58)	NA
Hot Water Tank Upgrade	27	0.164	$65	12	$7.33	$0.03	$6.75	$0.55	$3
Ducts (Existing to R-11)	68	0.413	$385	12	$43.44	$14.90	$17.00	$11.53	$27
Infiltration (caulk)	33	0.201	$191	12	$21.55	$7.23	$8.25	$6.07	$30
Furnace Upgrade Case 1	89	0.541	$687	12	$77.51	$19.51	$22.25	$35.75	$66
Ceiling (R-30 to R-38)	6	0.036	$240	30	$15.61	$1.32	$1.50	$12.80	$350

Retrofit Conservation Measures for Natural Gas Heated Homes: Cost-Effectiveness in Zone 2†

Measure	NG Savings (therms/yr.)	Annual CO_2 Reduction (tons)	Cost of Measure	Life of Retrofit Measure (years)	Annualized Cost of Measure	Capacity Benefit	Energy Savings Benefit	Net Annual cost of Measure	Cost per ton CO2 Reduction
Walls (R-0 to R11)	186	1.131	701	30	$45.60	$40.77	$46.50	($41.67)	NA
Floor (R-0 to R-19)	177	1.076	820	30	$53.34	$38.79	$44.25	($29.70)	NA
Ducts (Existing to R-11)	104	0.632	304	12	$34.30	$22.79	$26.00	($14.50)	NA
Ceiling (R-11 to R-30)	107	0.651	554	30	$36.04	$23.45	$26.75	($14.16)	NA
Vent Damper	53	0.322	142	12	$16.02	$11.62	$13.25	($8.85)	NA
Low-Flow Shower	48	0.292	45	12	$5.08	$1.45	$12.00	($8.37)	NA
Hot Water Tank Upgrade	27	0.164	65	12	$7.33	$0.81	$6.75	($0.23)	NA
Auto Ignition	40	0.243	225	12	$25.39	$8.77	$10.00	$6.62	$27
Infiltration (caulk)	28	0.170	191	12	$21.55	$6.14	$7.00	$8.41	$49
Furnace Upgrade Case 1	97	0.590	687	12	$77.51	$21.26	$24.25	$32.00	$54
Ceiling (R-30 to R-38)	16	0.097	202	30	$13.14	$3.51	$4.00	$5.63	$58

† The available measures, their costs and energy savings taken from Byers, R. et. al., Energy Efficiency Resources in Existing Residences Served by Natural Gas in Washington State, Washington State Energy Office, WAOENG-91-02, 1990. The capacity benefit calculation assumed an expanding market for natural gas, a capacity cost of $1 million per Mcf per day (Cahill, 1992), a peak day capacity factor of 0.1 for Low-Flow Showers and Hot Water Tank Upgrades, an 8.0 capacity factor for all other measures and a 5 percent discount rate.

TABLE B - 8

Carbon Dioxide Reduction for Cost-Effective Existing Homes Conservation Measures

	Zone 1	Zone 2
Units, 1980 and older	788,293	128,758
Proportion gas	0.27	0.32
Proportion electric	0.50	0.41
Number Units		
Gas	208,978	40,704
Electric	395,154	52,565
CO2 emission factor (tons/unit)		
Gas	3.137	3.776
Electric	17.401	24.234
Proportion of Homes that are Retrofit Candidates	0.10	0.10
2010 CO2 reduction (tons)		
Gas	65,556	15,369
Electric	687,607	127,386
Total	**753,163**	**142,755**

New Consumer Appliances

TABLE B - 9

Efficiency Improvement Potential From New Consumer Appliances†

Appliance	Efficiency Improvement	Appliance	Efficiency Improvement
Heating		Refrigerator/Freezer	
Improved fan efficiency	30%	Improved insulation	2%
Improved HP efficiency	23%	evacuated panels, refer.	16%
Improved HP indoor coils	10%	evacuated panels, freezer	28%
Improved gas furnaces (0.92 efficiency)	10%	Lighting	14%
Television	17%	Water Heating	
		Electric heaters (0.96 efficient)	10%
Cooking		Gas heaters (0.68 efficient)	
Improved gas oven insulation	7%		
Improved gas cooktop reflectance	3%	Clothes Washing/Drying	
Induction range and convection oven	32%	Efficiency improvement	13%
		Heat pump dryer	6%
		Front loading clothes washer	16%

† From Ciliano.

Direct Use Of Natural Gas

TABLE B - 10

Potential Carbon Dioxide Reduction From Direct Use of Natural Gas

Regional MBtu Reduction	6,000,000	8,000,000
Carbon Dioxide Emission Rate (ton/MBtu)	0.059	0.059
Carbon Dioxide Emissions (tons)	354,000	472,000
Washington's Proportion of Regional Emissions	0.60	0.60
Emission Reduction in Washington	212,400	283,200

Residential Lighting

TABLE B - 11

Potential Carbon Dioxide Reduction From Using Fluorescent Lighting

Regional Electricity Consumption for Lighting, aMW	290
Washington's Proportion of Electricity Consumption for Lighting	0.60
Washington's Electricity Consumption for Lighting, aMW	175
Reduction Potential of Compact Fluorescent Lighting	0.75
Washington's Reduction Potential, aMW	131
Carbon Dioxide Emission Rate, ton/aMW	3,528
Emission Reduction in Washington	462,200

Industrial Sector

Industrial Electricity Efficiencies

TABLE B - 12

Carbon Dioxide Reduction Resulting From Improved Industrial Efficiency

Regional Electricity Conservation Potential, aMW	830
Washington's Proportion of Conservation Potential	0.60
Washington's Electricity Conservation Potential, aMW	500
Carbon Dioxide Emission Rate, ton/aMW	3,528
Emission Reduction in Washington, tons	1,764,000

From the Northwest Power Planning Council

Industry Specific Measures

TABLE B - 13

Potential Industry Specific Efficiency Improvements and Carbon Dioxide Reductions†

	Petroleum	Pulp and Paper	Aluminum	Portland Cement and Glass
Projected 2010 Energy Consumption				
Electricity (millions of kWh)	991.2	8,921	18,266	510
Fossil Fuel (millions of Btu)	10,300	54,300	15,200	7,100
Reduction in Energy Consumption with State-of-the-Art Technology	33%	29%	16%	25%
Carbon Dioxide Emission Reduction				
Electricity Savings, tons	133,650	1,047,771	1,183,637	51,607
Fossil Fuel Savings, tons	272	1,259	194	566
Total, tons	133,922	1,049,031	1,183,831	52,174

† Assume carbon dioxide emission rates of 0.81 lbs/kWh for electricity and 160 lbs/million Btu for fossil fuels.

Transportation Sector

Feebates

TABLE B - 14

Potential Carbon Dioxide Reductions Resulting from an Automobile Feebate

Baseline Gasoline Consumption, millions of gallons	3,090
Reduction in Consumption resulting from FeeBate	15%
Consumption after a FeeBate, millions of gallons	463.5
Carbon Dioxide Emission Rate, ton/million gallons	9,500
Emission Reduction in Washington, tons	4,403,250

An Increased Gasoline Tax

TABLE B - 15

Potential Carbon Dioxide Reductions Resulting from Increasing the Tax on Gasoline by $1.00

	Base	With $1.00 tax	Difference
Gasoline cost	$1.50	$2.50	$1.00
Mileage	21.56	26.2	4.64
Cost/mile	0.06957	0.09542	0.02585
Base VMT 2010	64.696	55.136	-9.560
Cost, millions 1/2 x (change in miles driven) x (change in the cost per mile driven)			$124.56
Gasoline Consumption, millions of gallons	3,000	2,104	-896.
Carbon Dioxide Emission Rate, ton/million gallons			9,500
CO2 Reduction (millions of tons)			8.51
Cost Effectiveness (dollars per ton)			$14.6

Speed Limit Enforcement

TABLE B - 16

Carbon Dioxide Reduction Benefits from Enforcing the Speed Limit

	Vehicle Speed, MPH			Total
Miles Per Hour	55-60	60-65	65+	
VMT, billions, traveled at speed range	8.47	5.63	1.59	
Gas Consumption at Current Speed, millions of gallons	392.7	261.3	73.6	
Gas Consumption at 55 MPH, millions of gallons	374.0	227.2	56.6	
Gasoline Saved from Reduced Speed, millions of gallons	18.7	34.1	17.0	69.8
Carbon Dioxide Reduction, tons				662,800
Value of Gas Savings, millions of dollars				$104.6
Travel Time, millions of hours	147.2	90.2	22.7	
Travel Time at 55 mph, millions of hours	153.9	102.4	28.9	
Time Loss from Reduced Speed, millions of hours	6.7	12.3	6.2	25.2
Value of Time Loss, millions of dollars				$377.5
Total Cost				$272.9
Cost Effectiveness, Dollars per Ton				$412

Vehicle Inspection And Maintenance Programs

TABLE B - 17

Emission Reduction Benefit in the King, Pierce, and Snohomish County Area†

Cost Category	Seattle Metropolitan Area	Seattle Metropolitan Area	State Wide (Incremental to Seattle only program)	Exempt five year and younger Vehicles
	Current I & M	Enhanced I & M	Enhanced I & M	Enhanced I & M
Inspection Costs (x1000)	$15,109	$27,123	$40,685	$25,067
Failures	182,295	531,405	797,107	718,830
Repair Costs (x1000)	$9,412	$48,556	$72,835	$53,401
Inconvenience Costs (x1000)	$25,945	$40,811	$61,217	$38,820
Fuel Savings gallons	5,995,351	23,764,167	35,646,250	26,807,391
cost (x1000)	($6,650)	($35,646)	($53,469)	($37,799)
Total Cost (x1000)	$43,816	$80,844	$121,267	$79,489
Emission Reduction, tons	56,956	225,760	338,639	254,670
Cost Effectiveness, $/ton	769	358	358	312

† Estimates for King, Pierce, and Snohomish Counties only. State-wide estimates assume that 40 percent of VMT occurs in this area. Also assumes inspection costs of $12 and $18 for the Steady-State and IM240 tests, respectively, repair cost of $60 for cars failing the Steady State test, and $120 for cars failing the IM240 test. Fuel efficiency is expected to improve by 5.9 percent for vehicles repaired as a result of failing the Steady-State test and 12.6 percent for vehicles repaired as a result of the IM240 test. Finally, assumes a four-hour inconvenience time valued at $15 per hour to obtain the necessary repairs for the vehicles failing either test.

Remote Sensing

TABLE B - 18

Carbon Dioxide Reduction Benefits of a Remote Emission Sensing Program

Cost Category	With Current I&M Program	With Enhanced I&M Program
Program Cost	$500,000	$500,000
Number of Remote Sensing Tests	3,607,200	3,607,200
Number of Remote Sensing Failures	397,280	392,322
I&M Inspection cost	$7,151,035	$7,061,794
I&M Inspection Failures	238,368	235,393
Repair Cost	$14,302,069	$28,247,175
Fuel savings gallons	4,113,648	8,117,778
dollars	($6,170,472)	($12,176,666)
Inconvenience Costs	$14,302,069	$14,123,587
Total Cost	$31,584,701	$39,255,890
Carbon Dioxide Reduction (tons)	39,080	77,119
Cost Effectiveness	$808	$509

Tire Check/Inflation Added To I&M Test

TABLE B - 19

Carbon Dioxide Reduction Benefits from Adding a Tire Inflation Check to Vehicle Inspection Test

Cost Category	Cost
Added Inspection costs	$1,102,200
Gasoline Savings (Mil of gal)	3,680,930
Gasoline Savings (Mil of $)	$5,521,395
Total Cost	($4,419,195)
Carbon Dioxide Reduction, tons	34,969

The California Low Emission Vehicle Program

TABLE B - 20

Market Penetration Of Electric Vehicles

Year	Sales Requirement	Proportion of Vehicle Fleet
1997	0	0
1998	2%	0.10%
1999	2%	0.21%
2000	2%	0.31%
2001	5%	0.73%
2002	5%	1.00%
2003	10%	1.53%
2004	10%	2.08%
2005	10%	2.61%
2006	10%	3.10%
2007	10%	3.54%
2008	10%	3.87%
2009	10%	4.16%
2010	10%	4.47%

TABLE B - 20

Emission Reduction

Portion of fleet miles traveled with electric vehicles	4.47%
Fleet VMT in 2010 (millions)	64,696
Electric Vehicle VMT in 2010 (millions of miles)	2,892
Average Electric Vehicle Energy Consumption (kWh/mile)	0.54
Electricity Needed to Fuel Electric Vehicles (million kWh)	1,571
Carbon Dioxide from Combined Cycle Combustion Turbine (tons)	696,085
Carbon Dioxide from Gasoline Vehicles (tons, 23.2 mpg)	1,184,224
Emission Reduction From Electric Vehicles (tons)	488,139

(The California Low Emission Vehicle Program continued)

TABLE B - 21

Cost Effectiveness

Cost Premium	$10,000
Average Annual Emission Reduction (tons)	1.9
Lifetime (years)	10
Interest Rate	0.05
Discount present value of Emission Reduction (tons)	14.3
Cost Effectiveness	$701

A Vehicle Mileage Tax

TABLE B - 22

Carbon Dioxide Reduction Benefits of a $0.04 Vehicle Mileage Tax

	Base	With $0.04 per mile tax	Difference
Cost/mile (gasoline cost $1.50, mileage 21.56)	0.06957	0.10957	0.04
Base VMT 2010 (millions of miles)	64,696	46,095	-18,600
cost, millions 1/2 x (change in miles driven) x (change in the cost per mile driven)			$372
Gasoline Consumption, millions of gallons	3,003	2,137	-866
Carbon Dioxide Emission Rate, ton/million gallons			9,500
CO2 Reduction (millions of tons)			8.23
Cost Effectiveness (dollars per ton)			$45.2

Telecommuting

TABLE B - 23

Carbon Dioxide Reduction Benefits of Promoting Telecommuting

	1993	2010
Employment	1,426,000	2,356,961
Proportion Telecommuting	0.34%	3%
Number Telecommuting	4,848	70,709
VMT reduction	11,900,000	173,549,001
Miles per gallon	18.2	21.6
Gasoline Savings	654,622	8,034,676
Net Savings (increased home energy consumption)	589,160	7,231,208
Carbon Dioxide Reduction, tons	5,597	68,696

Electricity Generation Sector

Using Alternative Fuels to Produce Electricity

TABLE B - 24

Carbon Dioxide Reduction Benefits And Cost Effectiveness of Using Alternative Fuels to Produce Electricity

Alternative Energy Source	Average Energy Production aMW	Combined Cycle Combustion Turbine, Tons of Carbon Dioxide Emissions per aMW	Carbon Dioxide Emission Reduction of Alternative Energy Source, tons	Cost of Alternative Energy Source, millions	Cost Effectiveness of Alternative energy Source, dollars per ton
Wind	125	3,528	440,993		
Solar	9.3	3,528	32,810	9.78	297
Woody Residues	43.5	3,528	153,468	14.10	92
Chemical Recovery Boilers	116	3,528	409,248		NA
Agricultural Field Residues	50	3,528	176,400	22.78	129
Land fill Gas	140	3,528	493,920		NA

Using Animal Manure to Produce Electricity

TABLE B - 25

Carbon Dioxide Reduction Benefits And Cost Effectiveness of Using Manure to Produce Electricity

Herd Size	1000+	500 - 1000
Number of Cows	27,435	48,586
Number of Herds	18	65
Digestor Type	Plug Flow	Lagoon
Cost per Digestor	$44,286	$23,418
Total Annual Cost	$810,002	$1,517,095
Energy Production, aMW	2.96	5.25
Value of Energy Produced	$777,888	$1,374,444
Residual Cost	$32,114	$142,651
Carbon Dioxide Emission Reduction, tons	10,443	18,522
Reduction in Methane Emissions, tons	4,322	7,654
Methane Reduction in Carbon Dioxide Equivalent, tons	47,542	84,194
Total Carbon Dioxide Equivalent Emission Reduction, tons	57,985	102,716
Cost-Effectiveness, dollars per ton	$0.55	$1.39

Carbon Sequestration

Afforestation

TABLE B - 26

Per Acre Afforestation Costs

Tree Planting	
cost	$180
interest rate	5%
period	80
Annualized Cost	$9.19
Dry Cropland Rental Rate	$42.00
Total Annual Per Acre Cost	$51.19
Carbon Sequestration, tons	12.20
Cost Effectiveness	$4.19